U.S. Department of Transportation
Federal Highway Administration

Next-Generation Traffic Incident Management: Technology for Saving Lives (NextGen TIM Tech)

Photo Credit: Enforcement Engineering, Inc.

EMERGENCY VEHICLE LIGHTING

Emergency warning lights ahead are a cue to drivers to slow down, move over, and be cautious. The challenge is that there is no national standard for the color, placement, intensity, or flash pattern of emergency warning lights across police, fire, emergency medical services, transportation, and towing vehicles. *The Manual on Uniform Traffic Control Devices for Streets and Highways* (MUTCD) warns that "the use of too many lights at an incident scene can be distracting and can create confusion for approaching road users, especially at night."[1]

While emergency vehicle lights are not traffic control devices, they do form the basis for important visual communication that affects the way drivers interact with emergency responders stopped at roadway incidents. To make the most effective use of these lighting systems, responder agencies should strive for S-M-A-R-T use of warning lights.

***S**trategic placement*

The shape of the vehicle body, automotive glass, and vehicle lamps generally constrain the physical placement of lights. Defining the approximate dimensions of the responder vehicle is helpful. Flashing lights at the approximate height of a driver's head are most conspicuous.[2] At traffic incident scenes, lights that are sufficiently high for drivers to see them from a distance can help drivers observe the need to slow down and move over.

***M**eaningful messaging*

Motorists perceive red, blue, and amber in a descending order of most-to-least hazards present.[3] Aside from communicating hazards, systems with a sequencing of lights that shows a direction to drivers are desirable. Amber directional lights are viewed favorably because they create less anxiety and inform drivers where to go.[4]

Synchronization with other response vehicles is an important way that multiple response vehicles can work together to more effectively convey a message to motorists. Though presently difficult to implement across many agencies, lighting systems can be programmed to display the same color and pattern simultaneously among all of the vehicles from one agency.

***A**utomatic features*

Emergency vehicle lighting systems are increasingly tied to the vehicle systems in which they are installed. The controller area network (CAN bus) is an automotive standard that governs how vehicle systems communicate with each other. Braking, doors opening, gear selection, and other vehicle functions can be linked to emergency lighting systems to elicit a specific response. For example, many fire apparatus now dim forward-facing lights when the parking brake is set. This feature minimizes distraction for drivers in the opposite direction of travel and also reduces glare from the reflective rear markings of other emergency vehicles on the scene. Automatic light brightness and intensity adjustments are commonly made, based on ambient light (day or night).

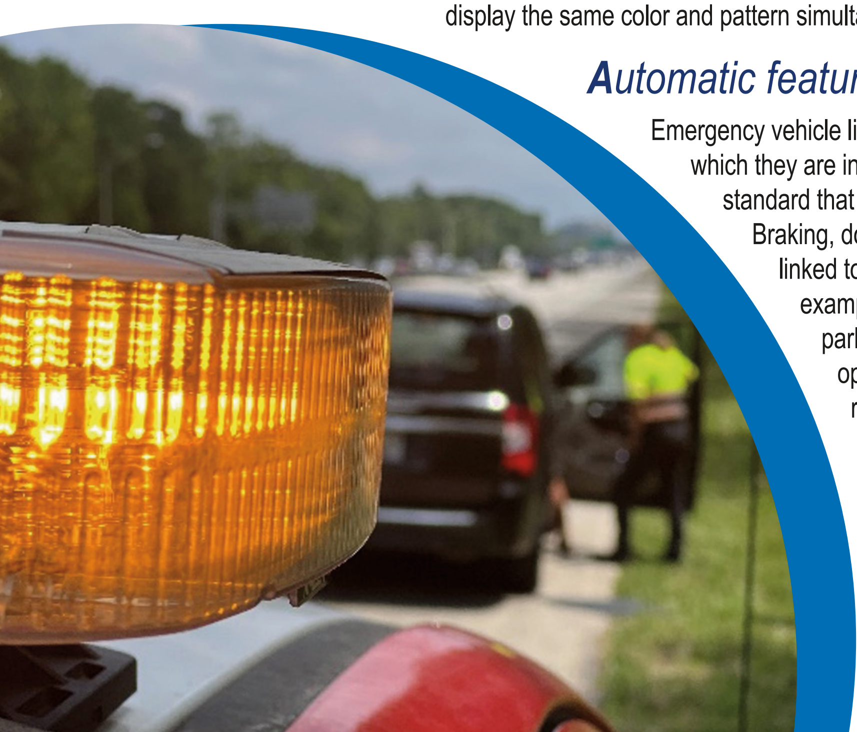

Photo Credit: Florida Department of Transportation. Emergency lighting in use at a roadside incident.

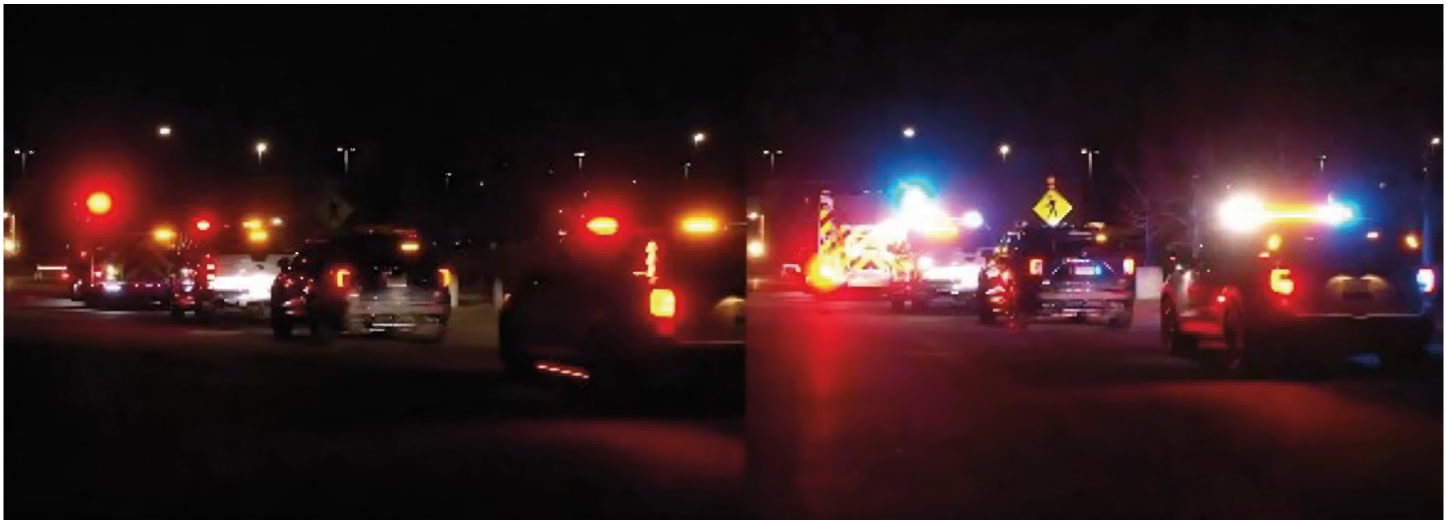

Photo Credit: Whelen Engineering Company, Inc. Comparison of calm versus chaotic scene lighting.

Reduced pattern and intensity

"Visual chaos" results when there are too many lights and too many different flash patterns. For this reason, the National TIM Responder Training Program encourages responders to reduce lighting when multiple responder vehicles are present.

Peak intensity is critical because it can be confounding at nighttime and during fog, snow, and other conditions. Daytime and nighttime intensity should vary. Steady burn lamps or those that do not go completely "off" between flashes are less confusing and more comfortable for approaching drivers.[5] In general, a lower intensity of lighting is recommended for stationary vehicles.[6]

Tiered approach

Attention-grabbing flash patterns are important for clearing traffic when an emergency vehicle is responding to a scene. Being seen means drivers will yield the right-of-way, and it also provides warning at critical conflict points such as intersections. Once on the scene, however, a calmer flash rate and fewer emergency lights can be used. After deploying temporary traffic control devices, the MUTCD states that fewer lights are needed. Again, the calmer scene with less modulation among lamps is viewed as a safer scene. Agency policy that addresses the use of reduced lighting is beneficial. Lighting technology is increasingly complementary to policy in helping change the use of lights in a variety of settings. Stepping lighting usage down from response mode, after initial arrival activities, and at a stable scene are examples of how a tiered approach might look.

Benefits

- Reducing forward-facing lights minimizes distraction for drivers in the opposite direction of travel.
- Eliminating forward-facing lights reduces glare from the reflective rear markings of other emergency vehicles on the scene.
- Fewer emergency lights at traffic incident scenes can reduce discomfort glare for approaching road users.[7]
- Calm flash patterns reduce "chaotic" and bright scenes that sometimes obscure pedestrian responders.[8,9]

Conclusion

Emergency vehicle lighting is an important part of TIM. To learn more about Next-Generation TIM Tech and technologies that your agency can use to protect motorists and responders after a traffic incident, please contact Joe Tebo, James Austrich, or Paul Jodoin, FHWA Office of Operations.

Photo Credit: Colorado Department of Transportation. Example of synchronized emergency vehicle lighting.

Resources

[1] FHWA. 2023. *Manual on Uniform Traffic Control Devices for Streets and Highways*. 11th Edition. Washington, DC: FHWA.

[2] Gibbons, R. B., S. E. Lee, B. Williams, and C. C. Miller. 2008. *Selection and Application of Warning Lights on Roadway Operations Equipment*. Washington, DC: National Academies Press. https://doi.org/10.17226/14190.

[3] Ullman, G., J. Ragsdale, and N. Chaudhary. 1998. *Highway Construction, Maintenance, and Service Equipment Warning Lights and Pavement Data Collection System Safety*. Report No. TX-99/3972-1. Texas Transportation Institute.

[4] Steele, D. A., J. M. Zabecki, L. Zimmerman, and Illinois Center for Transportation. 2013. *Improving the effectiveness of nighttime temporary traffic control warning devices. Volume 2, Evaluation of nighttime mobile warning lights*. Report No. ICT-R27-108. Illinois Center for Transportation.

[5] Emergency Responder Safety Institute. 2019. *Fire Apparatus Emergency Lighting Study Report*. https://www.respondersafety.com/news/news/2019/06/fire-apparatus-emergency-lighting-study-report/.

[6] Ibid.

[7] Cook, S., C. Quigley, and L. Clift. 1999. *Motor Vehicle Conspicuity: An Assessment of the Contribution of Retro Reflective and Fluorescent Materials*. London, England, UK: The Department of the Environment, Transport and the Regions.

[8] Kersavage, K., N. P. Skinner, J. D. Bullough, P. M. Garvey, E. T. Donnell, and M. S. Rea. 2018. "Investigation of Flashing and Intensity Characteristics for Vehicle-Mounted Warning Beacons." *Accident Analysis & Prevention* 119:23–28. https://doi.org/10.1016/j.aap.2018.06.008.

[9] Bullough, J., N. Skinner, and M. Rea. 2019. *Impacts of Flashing Emergency Lights and Vehicle-Mounted Illumination on Driver Visibility and Glare*, SAE Technical Paper 2019-01-0847. Warrenville, PA: SAE International. https://doi.org/10.4271/2019-01-0847.

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For more information, visit the FHWA EDC7 Next-Generation TIM Web Page.

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